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SEISMIC ANALYSIS OF MULTISTOREY RC BUILDINGS CONSIDERING THE SOIL STRUCTURE INTERACTION

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ABSTRACT

Influence of underlying soil on the seismic response of multi-story buildings can be neglected in case of stiff and very stiff soil and structure can be analysed assuming fixed base condition. However the seismic response of structure changes when the underlying, soil condition are soft soil deposit. Earthquake characteristics, travel path, soil property and soil structure interaction are the chief factors affect the seismic response of the structure. This study intends to find the seismic response of multi-storey building considering soil structure interaction. The objective of this study is to compare the effect of soil structure interaction on flexible base and fix base foundations considering different types of soil. The literature review pertaining to this study has been carried out with respect to effect of soil structure interaction on building frame, footings, tall sky-pod structure, low rise buildings and reinforced concrete moment resisting building frames in terms of base shear, mode shape, displacement response, acceleration response and other influence factors.

KEY WORDS: Soil-structure interaction, Time history, Response of structure, Base shear, SAP2000.

I. INTRODUCTION

Most of the civil engineering structure involves some type of structural element with direct contract with ground. Structural design of building for seismic force is primarily concerned with structure safety during major motion of ground. Bhuj earthquake of 26 January 2001 have demonstrated that strength along would not be sufficient for safety of structure during earthquake. Soil conditions are great deal to do with damage to structure during earthquake. Hence the investigation on energy transfer mechanism form soils to building during earthquake is critical for the seismic design of multistorey building. If the structure is high rise building and resting on relatively soft soil, the motion at base of structure may be significantly different than the free field surface motion, is referred to as soil structure interaction. Neglecting SSI is reasonable for light structures in relatively stiff soil such as low rise buildings. The response of the structure influences the motion of the soil and the response of the soil influences the motion of the structure is terms as soil structure interaction.

Several studies have been made on the effect of soil structure interaction problems to obtain more realistic analysis. There are two method of implementing soil structure interaction. First is substructure method in which soil material are used for interpolation of spring to the stiffness at the soil foundation interaction. Second is the direct approach, in which the soil and structure is represented as continuum and modelled together in a single accounting for both inertial and kinematic interaction using finite element method.

In present study, SSI analysis is carried out on multi-storey reinforced concrete framed buildings with various three type of soil resting on raft foundation. The effects of soil flexibility are incorporated in analysis using three types of soil based on shear modulus, poisons ratio and modulus of elasticity.

The study focus on the seismic behaviour of 20story reinforce concrete building and analysis of structure by using equivalent static method, response spectrum method and time history method has been carried out for rigid base and flexible base. The soil flexibility is including in the analysis using spring model and elastic continuum approach (FEM). The response spectrum method the data such as zone factor, type of soil etc. are applied from I.S.-1893 and time history method the actual record of accelelogram of bhuj earthquake is applied on the building and analysis of the building is carried out in SAP2000 V18software. The effect of SSI on various structural parameters i.e. natural time period, base shear, roof displacement result have been obtained by using both static and dynamic analysis.

II. METHODOLOGY

A. Structure Idealization

To study effect of soil structure interaction, a G+20 multistoried building frame was modeled in SAP2000 V18 software with fixed and flexible base. The plan of building is 17mx13.5m and total height of the building is 30m with floor to floor height of 3m each. Buildings were analyzed subject to seismic force under different soil condition like hard, medium and soft soil. 3D models are supported to be resting on raft foundation of 1.2m depth and was assumed to be suited in zone V as per IS 1893:2002. The important features of building are show in **table 1**

TABLE NO 1: DETAILS OF BUILDING

Type of structure: RCC Multistorey frame	
Number of stories	(G+20)
Typical storey height	3000 mm
Size of column	300x800 mm 230x600 mm
Size of beam	230x450 mm
Materials	M20, M25 and Fe415
Slab thickness	125 mm
Wall	230mm(external) 115mm(internal)
Unit weight of RCC	25 kN/m^3
Dead load of floor finishes	1 kN/m^2 (As per IS 875-1987 part1)
Live load on floor	2 kN/m^2 (As per IS 875-1987 part2)
Earthquake load	As per IS 1893-2002
Seismic zone	V
Response reduction factor(SMRF)	5
Importance factor	1

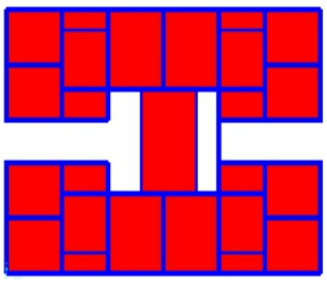

Fig. 1: Plan of Model

A. Soil Idealization

In this work the fixed base supports were replaced by the soil stiffness approach base of structure condition is spring base and soil media surrounding structure. Fixed supports are replaced by spring base support as per Gazetas formulas. Soil has been modeled using elastic continuum model i.e finite element method. Soil is discretized as solid media. According to EI Noggar and Rayhani, the horizontal distance of soil boundaries is assumed to be twice time of structure width and the bedrock depth is assumed 10m. Fixed condition is assumed at bottom of soil base. The soil dimensions are 34m long, 27m width and 10m depth. As per IS 1498-1970 code, the guideline available the different type of soil has been classi-

fied by various parameter such as, modulus of elasticity, shear modulus, poison ratio. Property of soil are given in table- 2

TABLE NO 2: PROPERTIES OF SOIL

Soil properties	Hard	Medium	Soft
Density(kN/m^3)	21	20	18
Poisson's ratio	0.3	0.39	0.4
Elastic modulus (kN/m^2)	50000	25000	15000
Shear modulus (kN/m^2)	19880	8990	5890

II. MODELING AND ANALYSIS

A. Time History Analysis

The linear time history analysis of the buildings on fix-base and flexible-base support has been carried out. The details of time history of Bhuj earthquake (2001) are as under. Fig.3 shows the acceleration time history of Bhuj earthquake.

a) Name of time history: Bhuj

b) Magnitude: 7.7

c) Peak ground acceleration: 1.038 m/sec2

d) Time for PGA: 46.9 second

e) Duration: long

f) Total no of acceleration records: 26706

g) Time step: 0.05 second

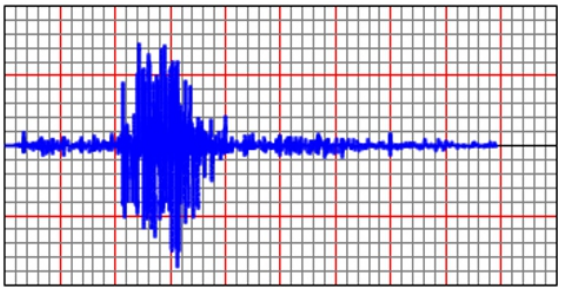

Fig. 2: Accelerogram of bhuj earthquake

B. Computational Modeling

Multistorey building frame with fixed base and flexible base condition subjected to seismic force were analyzed under different three type of soil condition like soft, medium and hard. The analysis is carried out in SAP2000 software considering soil structure interaction. Assigned fixed supports are replace by spring base support as per Gazetas formulas of spring stiffness. The soil is idealized in strata beneath the foundation, which consist of rectangular foundation having 34m long, 27m width and 10m height. The soil surrounding modeled is considering solid elements. Following the model have been considered.

Case 1: Twenty storey building having fixed base support.

Case 2: Twenty storey building having spring base support (Winkler approach)

Case 3: Twenty storey building resting on soil media (finite element method)

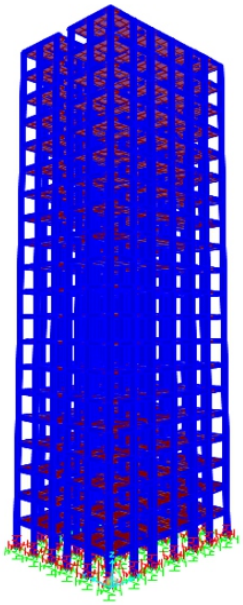

Fig. 3: Spring support model

IV. RESULTS AND DISCUSSION

Now it is possible to compare and analyze the effect of soil structure interaction in each model on different type of soil and model are performed using SAP2000 V18 software. The seismic analysis is carried out for three cases namely fixed base, spring base and finite element model of intergraded soil. The result in terms of natural period, lateral displacement and base shear for building model are present and compared for seismic analysis. The results are show in fig 6 to 12.

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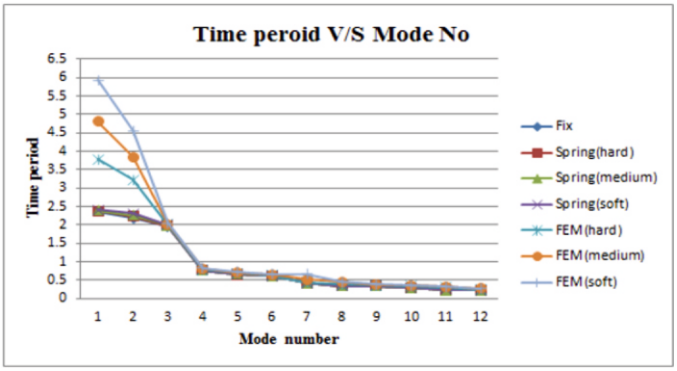

Fig. 5 : Time period v/s Mode number

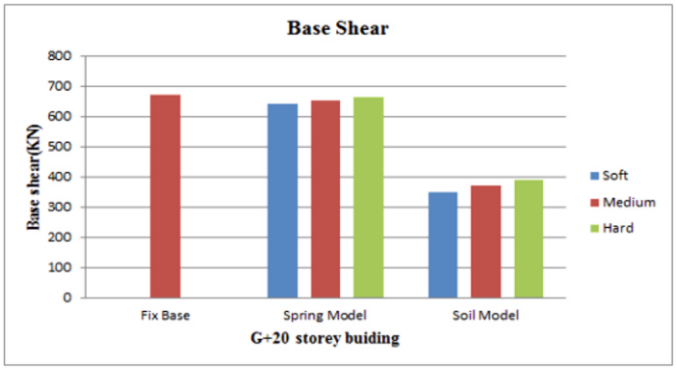

Fig. 6: Base shear for linear static analysis

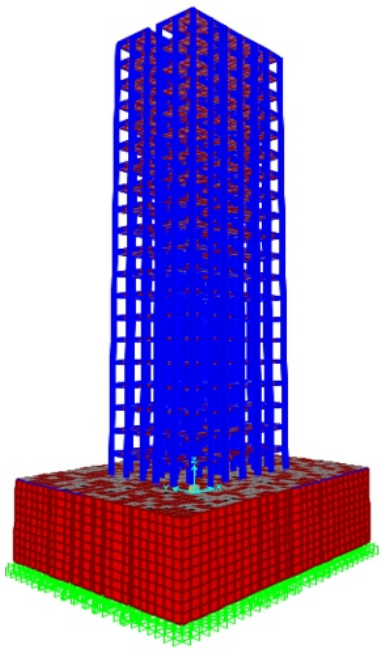

Fig. 4: 3D finite element model (soil media: 17mx13.5mx10m)

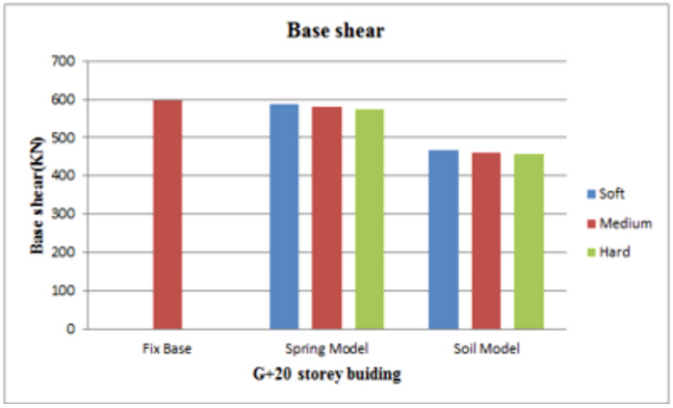

Fig. 7: Base shear for response spectrum

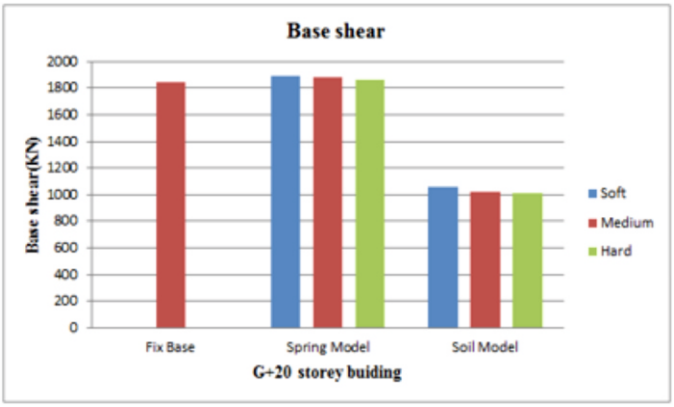

Fig. 8: Base shear for time history analysis

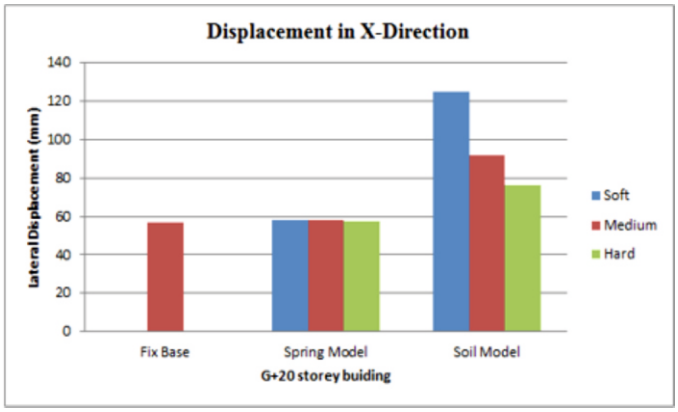

Fig. 9: Displacement for linear static analysis

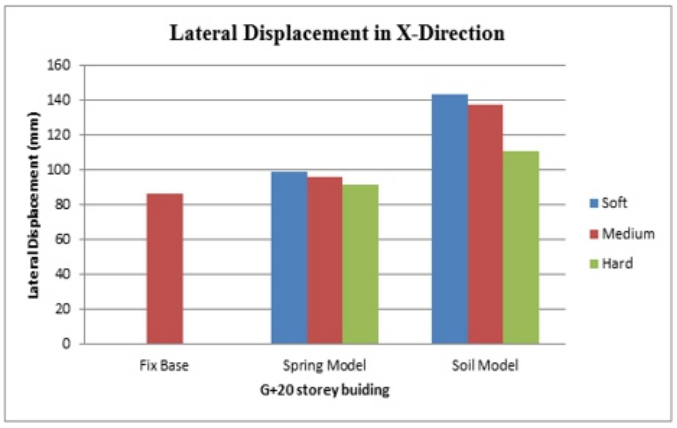

Fig. 10: Displacement for bhuj time history

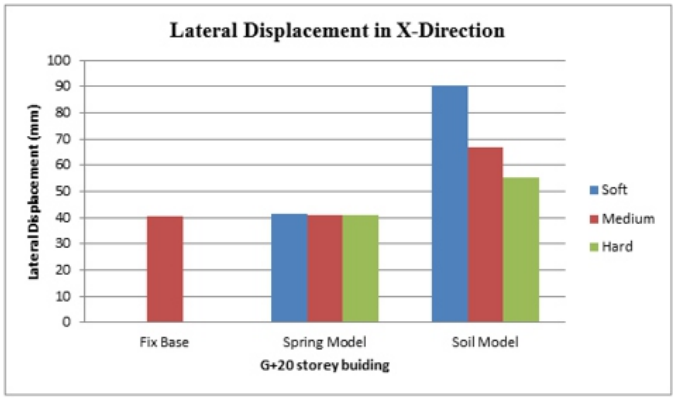

Fig. 11: Displacement for response spectrum

V. CONCLUSION

The following conclusions were drawn from the study.

(1) From the graph, we can getting the time period in first mode is higher 5.9second in soft soil as a finite element model compare lower time period 1.09second in fixed base model, so effect of soil must be consider in dynamic analysis of structure.

(2) From the graph of time period, we can observe that time period is different for first mode in all the building and after 3rd mode the time period is almost same.

(3) We are getting more deflection by modelling soil as solid object. There is very less deflection by modelling soil as spring.

(4) We are getting all must same base shear by modelling soil as spring, but there is significant different in base shear by modelling soil as solid.

(5) From the graph of base shear, the base shear for flexible base decreases as compared to fixed base.

(6) In case of bhuj time history, we are getting higher base shear by modelling soft soil compare to hard soil, so effect of soil there significant for tall building constructed on soft soil.

From about study we can concluded that by modelling soil as solid higher value of base shear and lateral deflection are obtain in soft soil, so for seismic analysis of building effect of soil must be consider in analysis.

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